Antimicrobial stewardship in remote primary healthcare across northern Australia

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Background

The high burden of infectious disease and associated antimicrobial use likely contribute to the emergence of antimicrobial resistance (AMR) in remote Australian Aboriginal communities. We aimed to develop and apply context-specific tools to audit antimicrobial use in the remote primary healthcare setting.

Methods

We adapted the General Practice version of the National Antimicrobial Prescribing Survey (GP NAPS) tool to audit antimicrobial use over 2-3 weeks in fifteen remote primary healthcare clinics across the Kimberley region of Western Australia (03/2018–06/2018), Top End of the Northern Territory (08/2017–09/2017) and far north Queensland (05/2018–06/2018). At each clinic we reviewed consecutive clinic presentations until 30 presentations where antimicrobials had been used were included in the audit. Data recorded included the antimicrobials used, indications and treating health professional. We assessed the appropriateness of antimicrobial use and functionality of the tool.

Results

We audited the use of 668 antimicrobials. Skin and soft tissue infections were the dominant treatment indications (WA: 35%; NT: 29%; QLD: 40%). Compared with other settings in Australia, narrow spectrum antimicrobials like benzathine benzylpenicillin were commonly given and the appropriateness of use was high (WA: 91%; NT: 82%; QLD: 65%). While the audit was informative, non-integration with practice software made the process manually intensive.

Conclusions

Patterns of antimicrobial use in remote primary care are different from other settings in Australia. The adapted GP NAPS tool functioned well in this pilot study and has the potential for integration into clinical care. Regular stewardship audits would be facilitated by improved data extraction systems.

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Abstract

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69

Introduction

Antimicrobial resistance (AMR) is a major healthcare issue. Compared with other countries, Australia currently has relatively low (albeit rising) rates of AMR, despite comparatively high rates of antimicrobial use in humans.[1-4] Remote regions in northern Australia, however, have some of the highest rates of AMR in the world; for example, at least 40% of *Staphylococcus aureus* community-associated isolates are methicillin-resistant (MRSA).[5-7] In comparison, rates of MRSA are about 15-20% elsewhere in Australia. Recognising the threat of emerging resistance to human health, the Australian Government Departments of Health and Agriculture published the first National Antimicrobial Resistance Strategy in June 2015.[8] The accompanying implementation plan highlighted areas for specific focus including identification of barriers and

80 enablers to antimicrobial stewardship (AMS) in Indigenous healthcare organisations to inform
81 development of setting-specific resources.[9] Addressing AMR in Indigenous primary healthcare
82 and coordinating AMS programs in partnership with Aboriginal and Torres Strait Islander
83 communities have been highlighted as priorities.[10]
84 Australia is a geographically large country. Northern Australia alone (the region north of the
85 Tropic of Capricorn) is approximately equivalent in area to Argentina and is sparsely populated.
86 The Northern Territory (NT), for example, has a population density of 0.2 people/km^2, the lowest
87 of Australia's eight jurisdictions.[11] Of its 245,000 residents, 30% live in rural areas (compared
88 with 10% Australia-wide).[12] Furthermore, while only 3% of the Australian population are
89 Aboriginal and/or Torres Strait Islander, this is 30% in the NT.[13] Of these Aboriginal and Torres
90 Strait Islander peoples, 81% live remotely (calculated using an index reflecting the community's
91 population size and level of access to goods and services), often many hundreds, if not thousands
92 of kilometres from the nearest urban center (Figure 1). In northern WA and Queensland, there
93 are similar sparsely populated communities. These communities have small healthcare clinics,
94 often Aboriginal Community Controlled Health Services, and antimicrobials are routinely
95 supplied through the Pharmaceutical Benefits Scheme (PBS). The health workforce is varied,
96 comprised of doctors, nurses, Aboriginal Health Practitioners and other health workers, many of
97 whom are on temporary contracts or work on a fly-in/fly-out basis. The mean annual staff
98 turnover rate in this setting is as high as 128%.[14] Usually more severe cases of infection require
99 treatment at a larger, urban hospital which involves air transport.
100 The high burden of infectious diseases in remote communities necessitates high antimicrobial
101 use, emphasising the need for good AMS.[15] However, specific information about prescribing in
102 remote settings is difficult to obtain. For example, the emergence of trimethoprim-resistant
103 clones of community associated MRSA in the Northern Territory[16], Western Australia (WA)[17]
104 and Queensland (QLD)[18] may be related to recommendations for co-trimoxazole in skin sore
105 treatment[19], but this hypothesis cannot be tested due to a lack of prescribing data.
106 Hospital-based AMS programs are tasked with monitoring antimicrobial use and implementing
107 AMS procedures in northern Australian hospitals (Kimberley Aboriginal Health Planning Forum
108 (KAHPF) stewardship committee, WA; Top End Health Service (TEHS) stewardship committee,
109 NT; Queensland Statewide Antimicrobial Stewardship Program (QSAMSP)) to meet
110 accreditation standards.[20, 21] Extension of stewardship into the remote primary healthcare sector
111 has been minimal due to a lack of related accreditation requirements and audit tools, limited
112 workforce and competing priorities. Authorised healthcare workers other than doctors, such as
113 registered nurses and Aboriginal Health Practitioners may supply and administer antimicrobials
114 in remote settings, in accordance with local treatment protocols and jurisdictional legislation.[22-24]
115 Context-specific tools are needed to capture prescribing practices and provide evidence-based
116 feedback and indicators to support best clinical practice and health outcomes.
117 Hospital-based National Antimicrobial Prescribing Surveys (NAPS) have been conducted since
118 2011 and provide a yearly snapshot of antimicrobial use, indications and appropriateness in
119 reference to local and national guidelines.[25] Participation in the NAPS is voluntary, 314 hospitals

120   nation-wide participating in the latest report. Appropriateness of antimicrobial use in the hospital
121   setting was 76%, cefazolin, ceftriaxone and amoxicillin-clavulanate being the most commonly
122   used.[25, 26] Other studies have highlighted some differences in antimicrobial use and challenges to
123   AMS in the regional and remote hospital setting.[27-30] Related AMS tools are being developed to
124   assess antimicrobial prescribing practices in urban General Practices (GP). Data on antimicrobial
125   use in GP is limited, particularly in remote primary healthcare. Some data collected through the
126   PBS and GP electronic software show the frequent use of penicillins with extended spectrum and
127   β-lactamase inhibitor combinations.[5] Rates of antimicrobial use have decreased in recent years,
128   but there continues to be overuse compared with guideline recommendations and inappropriate
129   use of antibiotics for respiratory indications like acute bronchitis and influenza.[5] Crucially,
130   antimicrobial use in the remote northern Australian setting is not captured by the PBS, leaving a
131   gap in our understanding of antimicrobial use. Given the primary healthcare setting of this audit,
132   we adapted and piloted the GP version of the NAPS tool (GP NAPS) in remote clinics in
133   northern WA, NT and Queensland.
134   Our aims were to:
135   1. Develop and pilot an audit tool of antimicrobial use for use in a remote primary
136   healthcare setting
137   2. In piloting the tool across 15 primary healthcare clinics in 3 jurisdictions, we sought to
138   describe:
139   a. Similarities and differences in prescribing patterns by jurisdiction and healthcare
140   professional status.
141   b. Appropriateness of prescribing.
142   c. Functionality of the audit tool in a qualitative sense
143   The following Materials & Methods section describes the process taken to achieve aim 1, and the
144   Results section presents the descriptive analysis for aim 2.
145
146   ## Materials & Methods
147   *Adaption of the GP NAPS tool*
148   Through an iterative process the study team, a multidisciplinary group of researchers, modified
149   the exiting GP NAPS audit tool. Adapted data fields included additions that reflect the health
150   professional types, antimicrobials and indications common in remote primary healthcare clinics,
151   while removing fields that were not relevant. It was designed to provide consistent data
152   interpretation across the different states and territories and by various auditor types (Appendix
153   A).
154   The study team comprised:
155   1. Clinical pharmacists working within the jurisdictions
156   2. National Centre for Antimicrobial Stewardship (NCAS) staff with experience in
157   developing and using the GP NAPS audit tool
158   3. Infectious diseases clinicians with expertise in antimicrobial stewardship or working in
159   remote health

160   4.   Individuals with key oversight roles for remote health

161   The study team provided relevant information on the differences between the various proposed

162   primary healthcare clinics and possible requirements for additions or alterations to the GP NAPS

163   audit tool. This required several rounds of template design and was conducted via email and

164   teleconferences between 16/10/2017 to 26/03/2018.

165   Criteria used to assess appropriateness of antimicrobial use were identical to those used in the

166   GP NAPS tool but tailored to local guidelines (Appendix B). In addition to the national

167   Therapeutic Guidelines[31] (to which access and promotion of are requirements of the National

168   Safety and Quality Health Service Standards[21] (NSQHS)), there are three regionally specific

169   clinical guidelines used across northern Australia: the Kimberley Clinical Protocols and

170   Guidelines (KCPG) in northern WA[22], the Central Australian Rural Practitioners Association

171   Standard Treatment Manual (CARPA) in the NT[23] and the Primary Clinical Care Manual

172   (PCCM) in Queensland.[24] To assess variation in these guidelines, recommended antibiotic

173   treatments for selected indications were compared (Table S1).

174   In this report we refer to antimicrobial 'use' instead of 'prescription' to reflect the range of health

175   professionals who are legally able to supply and administer antimicrobials in the remote setting,

176   specifically including doctors, remote area nurses and Aboriginal Health Practitioners.

177   *Selection of study sites*

178   Five primary healthcare clinics of varying capacities were selected by local project leads in each

179   of the three northern jurisdictions. These clinics were governed by the Kimberley Aboriginal

180   Medical Services (KAMS) in WA, TEHS in the NT and Torres and Cape Hospital and Health

181   Service (TCHHS) in Queensland.

182   *Audit process*

183   Following remote training by NCAS, local auditors reviewed consecutive clinic presentations to

184   identify the first 30 resulting in use of at least one antibiotic, antiviral, antifungal or antiparasitic

185   agent. The same patient could be included more than once if treatment had not previously been

186   given for the same indication.

187   Data were collected over a 2- to 3-week period via a standardised paper form (Appendix A) and

188   later transferred to a Microsoft Excel (Office 365) spreadsheet. Auditors in the Kimberley and

189   NT used remote access to electronic health records while in Queensland medical records were

190   reviewed on site. All auditors were employees of the involved health services, familiar with local

191   treatment guidelines.

192   Guideline compliance and appropriateness of each antimicrobial used was assessed against

193   agreed definitions (Appendix B)[25], based on the NSQHS and Antimicrobial Stewardship Clinical

194   Care Standard.[32] In brief, antimicrobial use was "Appropriate" if it followed the local or

195   Therapeutic Guidelines, or was endorsed by an infectious disease expert or clinical

196   microbiologist, or was the most narrow-spectrum antimicrobial that covers the causative

197   pathogen, or was a reasonable alternative to the guidelines (usually with justification for the

198   choice documented in the notes). The alternative category, "Inappropriate", included

199   antimicrobials used at the incorrect dose or too broad spectrum for the indication, or the choice

200 was unlikely to treat the causative pathogen, or the indication didn't require antimicrobial
201 treatment at all. The category "Not Assessable" was used if there was insufficient recorded
202 information. The NAPS team at NCAS provided phone and email support to the local audit
203 teams. Ten percent of antimicrobials audited in each facility were randomly reviewed by an
204 expert at NCAS to assess reliability and validity of local scoring.
205 *Data analysis*
206 The three jurisdictional datasets were transferred to a secure central repository and merged into a
207 single dataset for analysis in Stata 15.1.[33] Descriptive analyses of the data were conducted and
208 presented as proportions for categorical variables and medians for continuous data. No
209 inferential statistical analyses were performed for this pilot study.
210 *Qualitative survey of end user functionality of the GP NAPS tool*
211 A written questionnaire was used to survey local auditors to assess the practicality, usability,
212 feasibility, and generalisability of the audit tool to evaluate its suitability in context (Table S2).
213 We did not aim to test the construct validity or reliability of the tool.
214 *Ethical approval*
215 Ethical approval was obtained from each jurisdictional ethics committee (Western Australia
216 Aboriginal Health Ethics Committee (WAAHEC): 839; Top End Health Research Ethics
217 Committee (TEHREC): 2017-3012; Far North Queensland Human Research Ethics Committee
218 (FNQ HREC): HREC/18/QCH/3, PHA RD007329, SSA/18/FNQ/9,10,11,12,13,14). A waiver of
219 consent was granted because this research was retrospective, used de-identified data routinely
220 collected at the time of healthcare provision and thus carried no risk to participants.
221
222 Results
223 *Cohort characteristics*
224 668 antimicrobials for 529 patients between August 2017 and June 2018 were included (Table
225 1). The median age of patients was 23 years (interquartile range: 7–45 years), with 20% below 5
226 years. Females comprised 60% of patients. As expected, most patients were Aboriginal & Torres
227 Strait Islander people.
228 *Trends in antimicrobial use*
229 Nurses (305/668, 46%) and doctors (347/668, 52%) supplied/administered most of the
230 antimicrobials with some variation across jurisdictions (Table 2). Aboriginal & Torres Strait
231 Islander Health Practitioners rarely supplied/administered antimicrobials (4/668, <1%). This is
232 generally reflective of the staff composition, although we might expect a higher proportion of
233 Aboriginal Health Practitioners given that they comprise up to 10% of the workforce.[34, 35]Skin
234 and soft tissue infections (SSTI) were the most common indication for antimicrobial use in all
235 jurisdictions (WA: 35%; NT: 29%; QLD: 40%). The most frequently used antibiotics were
236 amoxicillin and benzathine benzylpenicillin. Co-trimoxazole was more commonly used in
237 Queensland than other states (WA: 7%; NT: 5%; QLD: 18%).
238 Figure 2 reflects how different presentations are managed. In WA and the NT, SSTIs made up a
239 slightly larger proportion of cases treated by nurses (42% and 32% respectively) compared with

240   doctors (29% and 24% respectively). Furthermore, lower respiratory tract infections (LRTI) were
241   treated by only doctors in WA, but by doctors and nurses in the NT. Secondary prophylaxis for
242   rheumatic heart disease was used by only doctors in Queensland (14/14), by mostly nurses in the
243   NT (18/22) and by doctors (3/6), nurses (2/6) and Aboriginal and Torres Strait Islander Health
244   Practitioners (1/6) in WA (not shown in Figure 2).
245   For SSTIs (mainly impetigo and folliculitis/abscess) in WA and the NT, benzathine
246   benzylpenicillin was more commonly used by nurses (43% and 29% respectively) than by
247   doctors (24% and 17% respectively) (Figure 3). Co-trimoxazole was used more in Queensland
248   (43%) than in WA (16%) and the NT (14%), especially by doctors.
249   The second most common syndrome leading to antimicrobial use in the NT was LRTI (18%;
250   WA: 8%, QLD: 4%). Remote Area Nurses treated most LRTIs in the NT (63%), using procaine
251   penicillin (most often for pneumonia) or azithromycin (bronchiectasis) for 41% (Figure S1).
252   Sexually transmitted infections were common in both WA and Queensland (10% and 12%
253   respectively; NT: 3%), with azithromycin frequently used (WA: 42%; QLD: 43%; NT: none),
254   however there was notably more ceftriaxone used in Queensland (WA: 4%; QLD: 25%; NT:
255   none) (Figure S2).
256   *Appropriateness of antimicrobial use*
257   More than 85% of antimicrobials used were considered appropriate in WA and the NT according
258   to local or Therapeutic Guidelines (205/225 and 159/193 respectively) (Figure 4). In Queensland,
259   65% (147/226) of antimicrobials used were considered appropriate. On average, 86% of
260   antimicrobials used by nurses were appropriate (WA: 91% (90/99); NT: 87% (122/141); QLD:
261   77% (47/61)) (Table S3), compared with 73% of those used by doctors (WA: 90%; NT: 73%;
262   QLD: 61%).
263   In all jurisdictions, dose and frequency of antimicrobial treatment were the most commonly
264   incorrect features of antimicrobial treatment (WA: 8%; NT: 7%; QLD: 1%) (Table S4). Other
265   commonly incorrect features included antimicrobials used for an indication that did not require
266   antimicrobial treatment (WA: 4%; NT: 7%; QLD: 10%), or with a duration that extended beyond
267   the recommended period (WA: 7%; NT: 2%; QLD: 4%).
268   Antimicrobials used for trauma and non-surgical wound infections contributed substantially to
269   inappropriate use by doctors in Queensland with 7/24 deemed appropriate (WA: 10/14; NT: 1/5).
270   For wound infections, co-trimoxazole was used in 10 of 15 cases in Queensland (0/10
271   appropriate due to incorrect spectrum of activity and/or incorrect dosing when compared to the
272   local or national guidelines) and in 4 of 7 in WA (4/4 appropriate). Overall, antimicrobials used
273   for impetigo were mostly appropriate (WA: 17/18; NT: 9/10; QLD: 15/21) for which co-
274   trimoxazole was used more often in Queensland (WA: 1/1 appropriate; NT: 2/2 appropriate;
275   QLD: 9/10 appropriate) compared with benzathine benzylpenicillin in WA (16/16 appropriate)
276   and the NT (7/8 appropriate).
277   Amoxicillin was often used inappropriately in Queensland by doctors for otitis media due to
278   incorrect dose or frequency (WA: 3/3 (two nurses) appropriate; NT: 8/9 (all nurses) appropriate;
279   QLD: 1/7 appropriate). Amoxicillin and amoxicillin-clavulanate were also used inappropriately

280   for pneumonia in Queensland (WA: 5/5 appropriate; NT: 7/12 appropriate; QLD: 0/5
281   appropriate).
282   *Qualitative survey of end user functionality of the GP NAPS tool*
283   While the tool was found to be acceptable in this context, auditors made some recommendations
284   for improvement (Table S2), such as the addition of some indications common in the remote
285   primary healthcare setting and training specific to the assessment of antimicrobials used in these
286   cases to improve consistency across jurisdictions. An additional category to grade antimicrobials
287   compliant with national guidelines but not with local guidelines was suggested as being useful
288   for future analyses and to identify variations in guidelines. Likewise, stratifying by medical
289   onsite and offsite (i.e. telephone order) review was suggested. Auditors reported a lack of detail
290   in many clinical records, including absence of imaging, laboratory results and other patient
291   medical history, which made identification of the indication and assessment of appropriateness
292   difficult in some cases, especially at clinics that used only paper-based medical records.
293   However, this is a challenge faced in any type of survey using administrative data, rather than a
294   shortcoming of the tool itself, and is a common limitation of AMS in general.[36] The audit
295   findings were reported back to each jurisdiction promptly which enabled identification of action
296   areas for their AMS programs. Auditors also highlighted areas in regional guidelines that could
297   be refined to improve interpretation by less locally experienced staff and where guidelines could
298   be updated to better align with the national Therapeutic Guidelines where appropriate.
299
300   **Discussion**
301   Our primary aim was to develop and pilot an audit tool of antimicrobial use for the remote
302   primary healthcare setting in Australia. Adaptations made to an existing tool for urban primary
303   healthcare use were relatively minor, incorporating health professionals, antimicrobials and
304   indications common in remote primary healthcare as well as the Indigenous status of the patient.
305   We gained useful preliminary insights on antimicrobial use, however these are descriptive
306   findings that will require confirmation in future studies given that this audit included only a
307   select few communities across northern Australia. Support from an expert team (at NCAS) was
308   required to ensure consistency in data quality and interpretation. Overall the tool was suitable for
309   use and was well received by the local health services in their first access to an audit tool.
310   The data demonstrated that SSTIs were the most frequent indications for antimicrobial use in all
311   three regions.[15, 37] This finding highlights the difference in morbidity profiles and patterns of
312   antimicrobial use between remote and urban communities, as upper respiratory tract infections
313   are typically the most common reason for an antimicrobial prescription in urban areas.[38]
314   The appropriateness of antimicrobial use was high compared with urban GP settings around
315   Australia. We found that narrow spectrum antibiotics like benzathine benzylpenicillin were
316   frequently used in the remote setting, in contrast to the broader spectrum antibiotics like
317   cephalexin and amoxicillin-clavulanate that are more often prescribed in urban primary
318   healthcare.[39] Strong local ownership of region-specific guidelines combined with regulatory
319   mechanisms to regulate the supply and provision of antimicrobials may have supported more

320   standardized antimicrobial use. Furthermore, a higher rate of monthly benzathine
321   benzylpenicillin injections for the treatment and prevention of rheumatic heart disease may
322   increase overall appropriateness compared with other parts of Australia that have a
323   proportionally smaller Indigenous population.
324   An important difference is that the health professionals supplying and administering
325   antimicrobials differ in remote areas from urban settings. This study showed that nurses
326   undertook a substantial proportion of this activity in remote areas whereas this is uncommon in
327   primary care in urban areas. Antimicrobial use by Aboriginal & Torres Strait Islander Health
328   Practitioners/Workers were lower than anticipated and further work is required to understand the
329   barriers to antimicrobial use by this group.[40-42]
330   Conflicts between multiple guidelines can influence antimicrobial use, and this issue can be
331   exacerbated by high staff turnover rates in the remote setting.[14] For example, at the time of the
332   audit, the regional Queensland guidelines (PCCM) included co-trimoxazole for impetigo but not
333   for folliculitis/abscess, while the KCPG and CARPA include co-trimoxazole for both conditions.
334   Similarly, co-trimoxazole for cellulitis was assessed as adequate treatment (i.e. in line with
335   currently accepted medical practice) but non-compliant with the Therapeutic Guidelines, PCCM
336   or other local guidelines. Some of these inconsistences have been resolved with release of the
337   10th edition of the PCCM in 2019[24], which lists co-trimoxazole as indicated for impetigo and
338   folliculitis/abscess, and for cellulitis in the Therapeutic Guidelines for people with an increased
339   risk of MRSA infection.[31] In future, electronic guidelines or decision support tools could be
340   updated in a more timely manner.
341   *Next steps*
342   This project aligns with the Australian Commission on Safety and Quality in Health Care's
343   objectives of setting safety and quality goals for Aboriginal and Torres Strait Islander people in
344   health service organisations, specifically agreeing on measures to analyse health outcomes and
345   measuring performance towards targets.[43, 44] Embedding this research within existing services
346   facilitates translation of research findings into ongoing practice and capacity building in AMS
347   across remote clinics.
348   Changes to electronic software in the practice to improve indication documentation would make
349   future auditing activity more efficient.[36] Automated data extraction and analysis would support
350   remote AMS audits, improve assessment of antimicrobial use and understanding of the
351   epidemiology of community-acquired infections, and could be linked to decision support tools.
352   Real-time antimicrobial use data would complement other recent efforts in AMR surveillance
353   across northern Australia (HOTspots: amrhotspots.com.au) and support clinical and public health
354   efforts that aim to improve clinical care and reduce the emergence of AMR. A corresponding
355   investment in workforce capacity in AMS is needed, across all relevant practitioner groups.
356   Local Aboriginal engagement and leadership is essential in addressing AMR, the underlying
357   burden of disease perpetuated by social determinants, and to prioritise the implementation of
358   ongoing AMS in this setting. Furthermore, a focus on AMS in the accreditation standards of

359 primary healthcare facilities is needed to enhance AMS activities and drive progress at the
360 systems level.
361

Conclusions

363 The development and piloting of an audit tool for antimicrobial use revealed that the morbidity
364 profile and antimicrobial use in remote Aboriginal primary healthcare clearly differ compared
365 with other primary care settings in Australia. The manual process of data collection was resource
366 intensive. Broader implementation and scale up will likely require improved methods for
367 automated data extraction.
368

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References

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375 1.   Cecchini M, Langer J, Slawomirski L. Antimicrobial Resistance in G7 Countries and Beyond:
376 Economic Issues, Policies and Options for Action. Organisation for Economic Co-operation and
377 Development. 2015.
378 2.   Antimicrobial resistance, Policy Insights. Organisation for Economic Co-operation and
379 Development. 2016.
380 3.   Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA, Goossens H, Laxminarayan R.
381 Global increase and geographic convergence in antibiotic consumption between 2000 and 2015.
382 Proceedings of the National Academy of Sciences of the United States of America. 2018;115(15):E3463-
383 E70.
384 4.   Van Boeckel TP, Gandra S, Ashok A, Caudron Q, Grenfell BT, Levin SA, Laxminarayan R. Global
385 antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. The Lancet
386 Infectious Diseases. 2014;14(8):742-50.
387 5.   Australian Commission on Safety and Quality in Health Care (ACSQHC). AURA 2019: third
388 Australian report on antimicrobial use and resistance in human health. Sydney: ACSQHC; 2019.
389 6.   Australian Commission on Safety and Quality in Health Care. Australian Passive Antimicrobial
390 Resistance Surveillance. First report: multi-resistant organisms. Sydney: ACSQHC; 2018.
391 7.   Tong SY, McDonald MI, Holt DC, Currie BJ. Global implications of the emergence of community-
392 associated methicillin-resistant Staphylococcus aureus in Indigenous populations. Clinical infectious
393 diseases : an official publication of the Infectious Diseases Society of America. 2008;46(12):1871-8.
394 8.   Responding to the threat of antimicrobial resistance: Australia's First National Antimicrobial
395 Resistance Strategy 2015–2019. Australian Government Departments of Health and Agriculture,
396 Commonwealth of Australia. 2015.
397 9.   Implementation Plan: Australia's First National Antimicrobial Resistance Strategy 2015–2019.
398 Australian Government Department of Health and Department of Agriculture and Water Resources,
399 Commonwealth of Australia. 2016.
400 10.   Bowen AC, Daveson K, Anderson L, Tong SY. An urgent need for antimicrobial stewardship in
401 Indigenous rural and remote primary health care. The Medical journal of Australia. 2019;211(1):9-11. e1.
402 11.   Australian Bureau of Statistics, 2016, 3218.0 - Regional Population Growth, Australia, viewed
403 28/04/2020,
404 https://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/3218.0Main%20Features752016.
405 12.   Australian Bureau of Statistics, 2019, 3101.0 - Australian Demographic Statistics, viewed
406 28/04/2020,
407 https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Sep%202019?OpenDocument.
408 13.   Australian Bureau of Statistics, 2016, 3238.0.55.001 - Estimates of Aboriginal and Torres Strait
409 Islander Australians, viewed 28/04/2020,
410 https://www.abs.gov.au/ausstats/abs@.nsf/mf/3238.0.55.001.
411 14.   Russell DJ, Zhao Y, Guthridge S, Ramjan M, Jones MP, Humphreys JS, Wakerman J. Patterns of
412 resident health workforce turnover and retention in remote communities of the Northern Territory of
413 Australia, 2013-2015. Hum Resour Health. 2017;15(1):52.
414 15.   Cuningham W, McVernon J, Lydeamore MJ, Andrews RM, Carapetis J, Kearns T, Clucas D,
415 Gundjirryirr Dhurrkay R, Tong SYC, Campbell PT. High burden of infectious disease and antibiotic use in
416 early life in Australian Aboriginal communities. Aust N Z J Public Health. 2019;43(2):149-55.
417 16.   Tong SY, Varrone L, Chatfield MD, Beaman M, Giffard PM. Progressive increase in community-
418 associated methicillin-resistant Staphylococcus aureus in Indigenous populations in northern Australia
419 from 1993 to 2012. Epidemiology and infection. 2015;143(7):1519-23.

420 17.   Coombs G, Pearson J, Robinson O. Western Australian methicillin-resistant Staphylococcus
421 aureus (MRSA) epidemiology and typing report. Perth, Australia. 2015.
422 18.   Guthridge I, Smith S, Horne P, Hanson J. Increasing prevalence of methicillin-resistant
423 Staphylococcus aureus in remote Australian communities: implications for patients and clinicians.
424 Pathology. 2019;51(4):428-31.
425 19.   Bowen AC, Tong SYC, Andrews RM, O'Meara IM, McDonald MI, Chatfield MD, Currie BJ,
426 Carapetis JR. Short-course oral co-trimoxazole versus intramuscular benzathine benzylpenicillin for
427 impetigo in a highly endemic region: an open-label, randomised, controlled, non-inferiority trial. The
428 Lancet. 2014;384(9960):2132-40.
429 20.   Australian Commission on Safety and Quality in Health Care. National Safety and Quality Health
430 Service Standards guide for hospitals. Sydney: ACSQHC. 2017.
431 21.   Australian Commission on Safety and Quality in Health Care. National Safety and Quality Health
432 Service Standards. 2nd ed. Sydney: ACSQHC. 2017.
433 22.   Kimberley Clinical Protocols and Guidelines (KCPG). 2016; https://www.kahpf.org.au/clinical-
434 protocols (date accessed: 01/10/2019).
435 23.   Remote Primary Health Care Manuals. (2017). CARPA Standard Treatment Manual (7th edition).
436 Alice Springs, NT: Centre for Remote Health.
437 24.   Queensland Health, Royal Flying Doctor Service (Queensland Section), Primary Clinical Care
438 Manual 10th edition 2019, the Rural and Remote Clinical Support Unit, Torres and Cape Hospital and
439 Health Service, Cairns.
440 25.   National Centre for Antimicrobial Stewardship and Australian Commission on Safety and Quality
441 in Health Care. Antimicrobial prescribing practice in Australian hospitals: results of the 2017 Hospital
442 National Antimicrobial Prescribing Survey. Sydney: ACSQHC; 2018.
443 26.   SA Health, Australian Commission on Safety and Quality in Health Care. Antimicrobial use in
444 Australian hospitals: 2016 annual report of the National Antimicrobial Utilisation Surveillance Program.
445 Sydney: ACSQHC; 2018.
446 27.   Bishop J, Kong DC, Schulz TR, Thursky KA, Buising KL. Meeting the challenge for effective
447 antimicrobial stewardship programs in regional, rural and remote hospitals - what can we learn from the
448 published literature? Rural Remote Health. 2018;18(2):4442.
449 28.   Bishop JL, Schulz TR, Kong DCM, Buising KL. Qualitative study of the factors impacting
450 antimicrobial stewardship programme delivery in regional and remote hospitals. The Journal of hospital
451 infection. 2019;101(4):440-6.
452 29.   Broom A, Broom J, Kirby E. Cultures of resistance? A Bourdieusian analysis of doctors' antibiotic
453 prescribing. Social science & medicine (1982). 2014;110:81-8.
454 30.   Bishop JL, Schulz TR, Kong DCM, James R, Buising KL. Similarities and differences in antimicrobial
455 prescribing between major city hospitals and regional and remote hospitals in Australia. Int J Antimicrob
456 Agents. 2019;53(2):171-6.
457 31.   eTG complete [Internet]. Melbourne: Therapeutic Guidelines Limited; 2015 Jul.
458 https://tgldcdp.tg.org.au/etgAccess (date accessed: 5/09/2019).
459 32.   Australian Commission on Safety and Quality in Health Care. Antimicrobial Stewardship in
460 Australian Health Care 2018. Sydney: ACSQHC; 2018.
461 33.   StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.
462 34.   Zhao Y, Russell DJ, Guthridge S, Ramjan M, Jones MP, Humphreys JS, Carey TA, Wakerman J.
463 Long-term trends in supply and sustainability of the health workforce in remote Aboriginal communities
464 in the Northern Territory of Australia. BMC Health Serv Res. 2017;17(1):836.
465 35.   Wright A, Briscoe K, Lovett R. A national profile of Aboriginal and Torres Strait Islander Health
466 Workers, 2006-2016. Aust N Z J Public Health. 2019;43(1):24-6.

467   36.   Hawes LA, Turner L, Buising KL, Mazza D. Workflow-based data solutions are required to support
468   antimicrobial stewardship in general practice. BMJ Open Qual. 2019;8(3).
469   37.   Thomas L, Bowen AC, Ly M, Connors C, Andrews R, Tong SYC. Burden of skin disease in two
470   remote primary healthcare centres in northern and central Australia. Intern Med J. 2019;49(3):396-9.
471   38.   Australian Commission on Safety and Quality in Health Care (ACSQHC). AURA 2019:
472   supplementary data. Sydney: ACSQHC; 2019.
473   39.   Hawes L, Turner L, Buising K, Mazza D. Use of electronic medical records to describe general
474   practitioner antibiotic prescribing patterns. Aust J Gen Pract. 2018;47(11).
475   40.   Jongen C, McCalman J, Campbell S, Fagan R. Working well: strategies to strengthen the
476   workforce of the Indigenous primary healthcare sector. BMC Health Serv Res. 2019;19(1):910.
477   41.   McCalman J, Campbell S, Jongen C, Langham E, Pearson K, Fagan R, Martin-Sardesai A,
478   Bainbridge R. Working well: a systematic scoping review of the Indigenous primary healthcare workforce
479   development literature. BMC Health Serv Res. 2019;19(1):767.
480   42.   Wakerman J, Humphreys J, Russell D, Guthridge S, Bourke L, Dunbar T, Zhao Y, Ramjan M,
481   Murakami-Gold L, Jones MP. Remote health workforce turnover and retention: what are the policy and
482   practice priorities? Hum Resour Health. 2019;17(1):99.
483   43.   National Safety and Quality Health Service Standards: User Guide for Aboriginal and Torres Strait
484   Islander Health, Australian Commission on Safety and Quality in Health Care. 2017.
485   44.   Improving care for Aboriginal and Torres Strait Islander People. Resource 1. Setting safety and
486   quality goals for Aboriginal and Torres Strait Islander people in health service organisations. Australian
487   Commission on Safety and Quality in Health Care. 2016.

488

Descriptive characteristics of audit sample population.

A WA: Kimberley region of Western Australia; NT: Top End of the Northern Territory; QLD: far north Queensland

B IQR: Interquartile range

	WA[A]	NT[A]	QLD[A]	Total
Audit dates	02/03/2018–02/06/2018	28/08/2017–03/09/2017	10/05/2018–15/06/2018	28/08/2017–15/06/2018
Unique patients	186 (35%)	162 (31%)	181 (34%)	529
Antimicrobials used	243 (36%)	196 (29%)	229 (34%)	668
Antimicrobials used with available microbiological result	36 (15%)	34 (17%)	82 (36%)	152 (23%)
Age, years (median [IQR[B]])	22 [5–44]	24 [8–46]	23 [8–44]	23 [7–45]
Sex (M:F)	39:61	33:67	49:51	40:60
Aboriginal & Torres Strait Islander	169 (91%; 8 unknown)	153 (94%)	141 (78%; 10 unknown)	463 (88%; 18 unknown)

Frequency (n (%)) of antimicrobial use by health professional, syndrome and antimicrobial.

[A] WA: Kimberley region of Western Australia; NT: Top End of the Northern Territory; QLD: far north Queensland

[B] A&TSI: Aboriginal and Torres Strait Islander

[C] SSTI: skin and soft tissue infection; GI: gastrointestinal infection; STI: sexually transmitted infection; LRTI: lower respiratory tract infection; RHD: rheumatic heart disease [D] Other: all syndromes/antimicrobials with frequency <10% in every jurisdiction

		WA[A]	NT[A]	QLD[A]	Total
Health professional	Doctors	130 (53%)	51 (26%)	166 (72%)	347 (52%)
	Nurses	100 (41%)	142 (72%)	63 (28%)	305 (46%)
	A&TSI[B] health practitioner	1 (<1%)	3 (2%)	0 (0%)	4 (1%)
	Unknown	12 (5%)	0 (0%)	0 (0%)	12 (2%)
	Total	243 (100%)	196 (100%)	229 (100%)	668 (100%)
Syndrome[C]	SSTI	86 (35%)	57 (29%)	92 (40%)	235 (35%)
	GI	28 (12%)	19 (10%)	19 (8%)	66 (10%)
	STI	24 (10%)	6 (3%)	28 (12%)	58 (9%)
	LRTI	20 (8%)	35 (18%)	8 (4%)	63 (9%)
	RHD	6 (2%)	22 (11%)	14 (6%)	42 (6%)
	Other[D]	79 (33%)	57 (29%)	68 (30%)	204 (31%)
	Total	243 (100%)	196 (100%)	229 (100%)	668 (100%)
Antimicrobial	Benzathine benzylpenicillin	37 (15%)	44 (22%)	31 (14%)	112 (17%)
	Amoxicillin	27 (11%)	27 (14%)	24 (10%)	78 (12%)
	Co-trimoxazole	16 (7%)	10 (5%)	42 (18%)	68 (10%)
	Other[D]	163 (67%)	115 (59%)	132 (58%)	410 (61%)
	Total	243 (100%)	196 (100%)	229 (100%)	668 (100%)

Figure 1

Map adapted from the Australian Bureau of Statistics, showing location and population of discrete Indigenous communities in northern Australia (i.e. above the Tropic of Capricorn (blue line)).

Source: Australian Bureau of Statistics, 2006, Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities, cat. no. 4710.0, viewed 5 May 2020, https://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4710.0Appendix42006?opendocument&tabname=Notes&prodno=4710.0&issue=2006&num=&view=

Reported usual population
of discrete Indigenous communities

● 500 people or more

● 200 – 499

● 50 – 199

· Less than 50 people

0 ——————— 1000

Kilometres
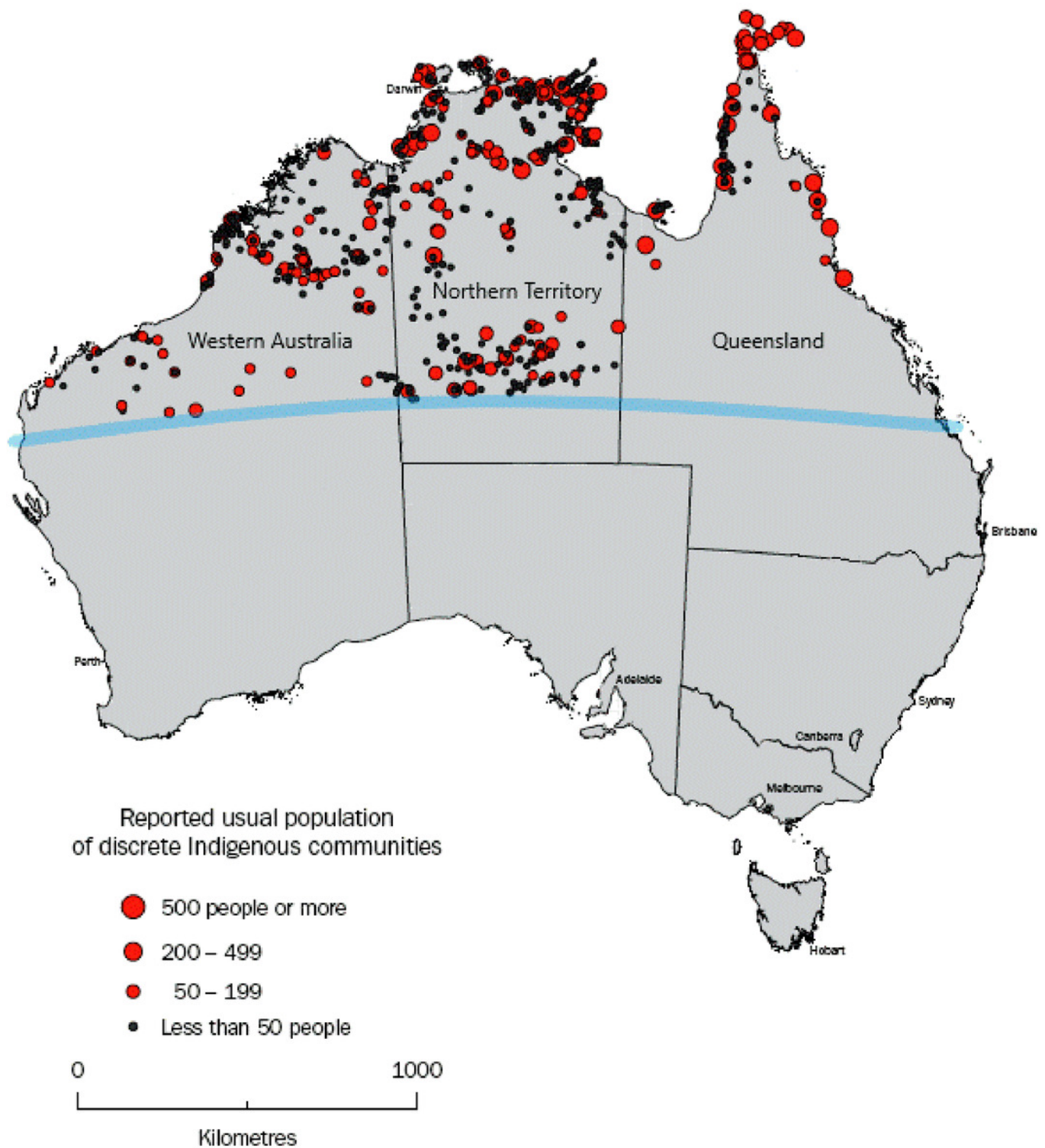
Figure 2

Antimicrobial use by health professional and syndrome.

Frequency of antimicrobial use by health professional and syndrome in WA (Kimberley), the NT (Top End) and QLD (far north Queensland). Numbers in middle of columns are the number (not percentage) of antimicrobials used for that health professional/syndrome group. Total number of antimicrobials: WA – 230, NT – 193, QLD – 229. *Other: all syndromes with frequency <5%
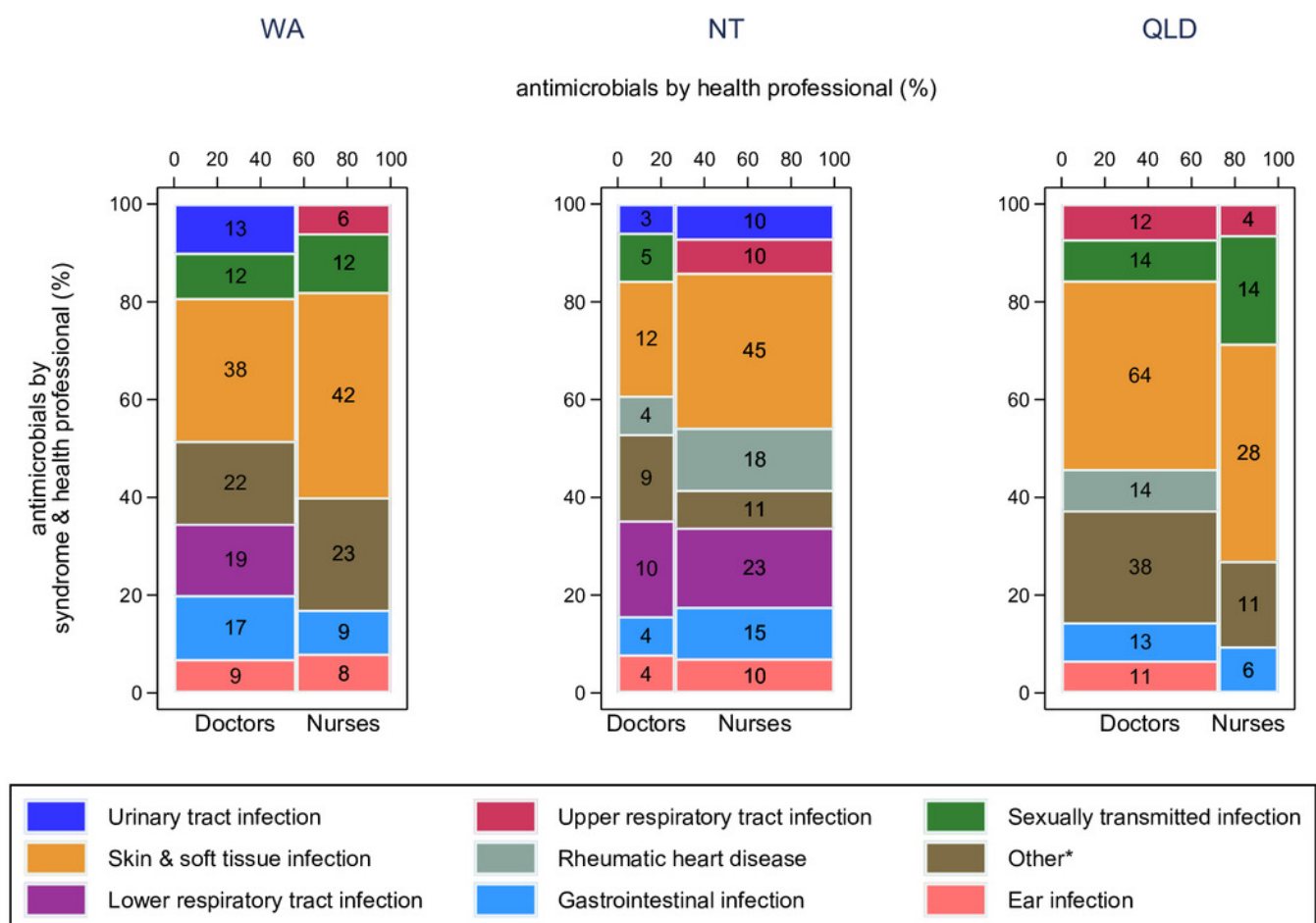
Figure 3

Antimicrobial use by health professional and antimicrobial for skin and soft tissue infections.

Frequency of antimicrobial use by health professional and antimicrobial for skin and soft tissue infections in WA (Kimberley), NT (Top End) and QLD (far north Queensland). Numbers in middle of columns are the number (not percentage) of antimicrobials used for that health professional/antimicrobial group. Total number of antimicrobials: WA – 80, NT – 57, QLD – 92. *Other: all antimicrobials with frequency <5%
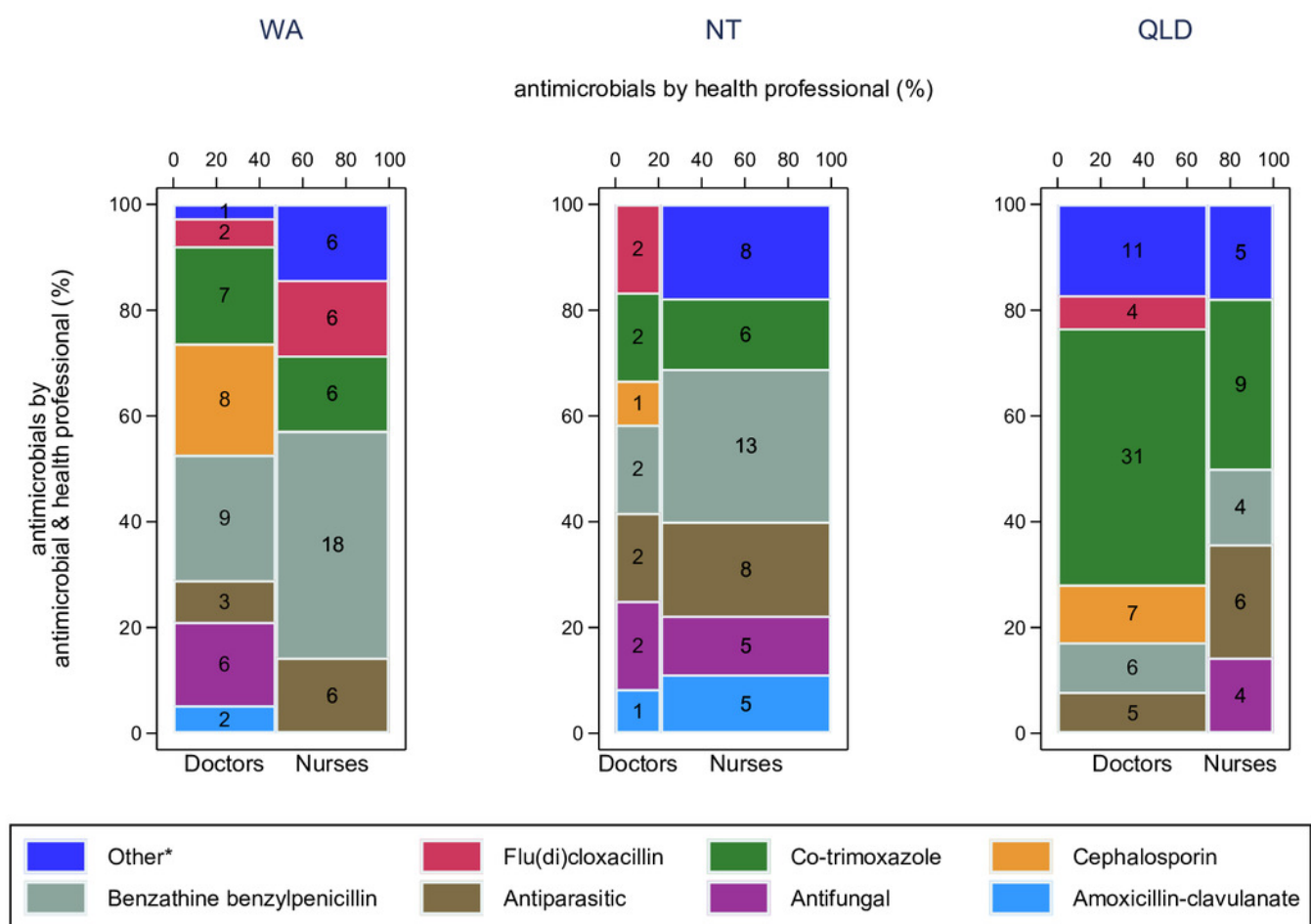
Figure 4

Appropriateness of antimicrobial use by doctors and nurses.

Appropriateness of antimicrobial use by doctors and nurses, by jurisdiction (WA (Kimberley),

NT (Top End) and QLD (far north Queensland). Appropriate: Optimal or Adequate,

Inappropriate: Suboptimal or Inadequate.